

1 **CLAIMS:**

2 1. A chemical-mechanical polishing (CMP) method comprising:
3 applying a solid abrasive material to a substrate;
4 polishing the substrate with the abrasive material;
5 flocculating at least a portion of the abrasive material on the
6 substrate; and

7 removing at least a majority portion of the flocculated portion of
8 the abrasive material from the substrate.

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10 2. The CMP method of claim 1, wherein applying a solid
11 abrasive material comprises applying a CMP slurry comprising
12 substantially dispersed, solid abrasive material to the substrate and
13 polishing the substrate comprises polishing the substrate with the slurry.

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15 3. The CMP method of claim 1, wherein applying a solid
16 abrasive material comprises applying a polishing pad comprising solid
17 abrasive material to the substrate and polishing the substrate comprises
18 polishing the substrate with the pad.

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20 4. The CMP method of claim 1, wherein the abrasive material
21 comprises ceria.

1 5. The CMP method of claim 1, wherein a temperature of the
2 substrate during the flocculating does not exceed about 40 degrees
3 Celsius (°C).

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5 6. The CMP method of claim 1, wherein the flocculating occurs
6 after the polishing.

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8 7. The CMP method of claim 6, wherein the flocculating is
9 performed on a secondary platen of a CMP tool.

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11 8. The CMP method of claim 6, wherein the flocculating is
12 performed during spray action within a CMP tool.

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14 9. The CMP method of claim 6, wherein the flocculating is
15 performed during immersion in an aqueous bath.

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17 10. The CMP method of claim 6, wherein the flocculating is
18 performed in conjunction with polyvinyl alcohol brush scrubbing of the
19 substrate.

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21 11. The CMP method of claim 6, wherein the flocculating is
22 performed prior to cleaning by high-pressure spray action.

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3 12. A CMP method comprising:

4 applying a solid abrasive material to a substrate;

5 polishing the substrate with the abrasive material;

6 applying a surfactant comprising material to the substrate and
7 flocculating at least a portion of the abrasive material with the surfactant
8 comprising material;

9 removing at least a majority portion of the flocculated portion of
10 the abrasive material from the substrate.

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12 13. The CMP method of claim 12, wherein applying a solid
13 abrasive material comprises applying a CMP slurry comprising
14 substantially dispersed, solid abrasive material to the substrate and
15 polishing the substrate comprises polishing the substrate with the slurry.

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17 14. The CMP method of claim 12, wherein applying a solid
18 abrasive material comprises applying a polishing pad comprising solid
19 abrasive material to the substrate and polishing the substrate comprises
20 polishing the substrate with the pad.

1 15. The CMP method of claim 12, wherein the abrasive material
2 comprises ceria.

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4 16. The CMP method of claim 6, wherein a concentration of the
5 surfactant in the surfactant comprising material comprises about 10
6 micrograms per milliliter ($\mu\text{g}/\text{ml}$) to about 10,000 $\mu\text{g}/\text{ml}$.

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8 17. The CMP method of claim 16, wherein the concentration
9 comprises about 100 $\mu\text{g}/\text{ml}$ to about 1,000 $\mu\text{g}/\text{ml}$.

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11 18. The CMP method of claim 12, wherein a temperature of the
12 substrate during the flocculating does not exceed about 40 °C.

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14 19. The CMP method of claim 12, wherein the surfactant
15 comprising material is applied after the polishing.

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17 20. The CMP method of claim 12, wherein the flocculating
18 further comprises complexing at least a portion of the abrasive material
19 with the surfactant.

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21 21. The CMP method of claim 12, wherein the surfactant
22 comprises a cationic surfactant.

1 22. The CMP method of claim 21, wherein the cationic
2 surfactant comprises a quaternary ammonium substituted salt.

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4 23. The CMP method of claim 22, wherein the quaternary
5 ammonium substituted salt comprises a quaternary ammonium halide.

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7 24. The CMP method of claim 23, wherein the quaternary
8 ammonium halide comprises a cetyltrimethylammonium bromide.

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10 25. The CMP method of claim 23, wherein the quaternary
11 ammonium halide comprises a polyethoxylated quaternary ammonium
12 halide.

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1 26. A CMP method comprising:
2 applying a CMP slurry comprising substantially dispersed, solid
3 abrasive material to a substrate;
4 polishing the substrate with the slurry;
5 applying to the substrate a surfactant comprising material that
6 exhibits the characteristic of decreasing a settling time for the abrasive
7 material in an aqueous dilution of the slurry;
8 removing at least a majority portion of the abrasive from the
9 substrate.

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11 27. The CMP method of claim 26, wherein the abrasive material
12 comprises ceria.

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14 28. The CMP method of claim 26, wherein a temperature of the
15 aqueous dilution does not exceed about 40 °C.

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17 29. The CMP method of claim 26, wherein the surfactant
18 comprising material is applied after the polishing.

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20 30. The CMP method of claim 26, wherein complexing between
21 at least a portion of the abrasive material and the surfactant forms
22 floccule.

31. The CMP method of claim 26, wherein the surfactant comprises a cationic surfactant.

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3 32. A CMP method comprising:

4 applying a CMP slurry comprising substantially dispersed, solid
5 abrasive material to a substrate;

6 polishing the substrate with the slurry;

7 applying to the substrate a surfactant comprising material, wherein
8 the surfactant exhibits a one-hour settling rate constant of greater than
9 0.035 for the abrasive material in an aqueous mixture of about 0.1
10 weight percent surfactant and about 1 weight percent slurry;

11 removing at least a majority portion of the abrasive material from
12 the substrate.

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14 33. The CMP method of claim 32, wherein the abrasive material
15 comprises ceria.

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17 34. The CMP method of claim 32, wherein a temperature of the
18 aqueous mixture does not exceed about 40 °C.

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20 35. The CMP method of claim 32, wherein the settling rate
21 constant is greater than about 0.09.

1 36. The CMP method of claim 32, wherein the surfactant
2 comprising material is applied after the polishing.

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4 37. The CMP method of claim 32, wherein complexing between
5 at least a portion of the abrasive material and the surfactant forms
6 floccule.

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8 38. The CMP method of claim 32, wherein the surfactant
9 comprises a cationic surfactant.

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1 39. A CMP method comprising:
2 applying a ceria-based solid abrasive material to a substrate;
3 polishing the substrate with the abrasive material;
4 applying a cationic surfactant comprising material to the substrate
5 and flocculating at least a portion of the abrasive material; and
6 removing at least a majority portion of the flocculated portion of
7 the abrasive material from the substrate.

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9 40. The CMP method of claim 39, wherein applying a solid
10 abrasive material comprises applying a CMP slurry comprising
11 substantially dispersed, solid abrasive material to the substrate and
12 polishing the substrate comprises polishing the substrate with the slurry.

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14 41. The CMP method of claim 39, wherein applying a solid
15 abrasive material comprises applying a polishing pad comprising solid
16 abrasive material to the substrate and polishing the substrate comprises
17 polishing the substrate with the pad.

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19 42. The CMP method of claim 39, wherein a concentration of
20 the cationic surfactant in the surfactant comprising material comprises
21 about 10 micrograms per milliliter ($\mu\text{g}/\text{ml}$) to about 10,000 $\mu\text{g}/\text{ml}$.

1 43. The CMP method of claim 42, wherein the concentration
2 comprises about 100 $\mu\text{g}/\text{ml}$ to about 1,000 $\mu\text{g}/\text{ml}$.

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4 44. The CMP method of claim 39, wherein a temperature of the
5 substrate during the flocculating does not exceed about 40 °C.

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7 45. The CMP method of claim 39, wherein the surfactant
8 comprising material is applied after the polishing.

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10 46. The CMP method of claim 39, wherein the flocculating
11 further comprises complexing at least a portion of the abrasive material
12 with the cationic surfactant.

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14 47. The CMP method of claim 39, wherein the cationic
15 surfactant comprises a quaternary ammonium substituted salt.

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1 48. A CMP method comprising:

2 applying a solid abrasive material to a substrate;

3 polishing the substrate with the abrasive material;

4 after polishing, brush scrubbing the substrate using a scrubbing
5 solution comprising a surfactant material to flocculate and remove at
6 least a majority portion of the abrasive material.

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8 49. The CMP method of claim 48, wherein applying a solid

9 abrasive material comprises applying a CMP slurry comprising
10 substantially dispersed, solid abrasive material to the substrate and
11 polishing the substrate comprises polishing the substrate with the slurry.

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13 50. The CMP method of claim 48, wherein applying a solid
14 abrasive material comprises applying a polishing pad comprising solid
15 abrasive material to the substrate and polishing the substrate comprises
16 polishing the substrate with the pad.

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18 51. The CMP method of claim 48, wherein the abrasive material
19 comprises ceria.

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21 52. The CMP method of claim 48, wherein a temperature of the
22 substrate during the flocculating does not exceed about 40 °C.

1 53. The CMP method of claim 48, wherein the flocculating
2 further comprises complexing at least a portion of the abrasive material
3 with the surfactant material.

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5 54. The CMP method of claim 48, wherein the surfactant
6 material comprises a cationic surfactant.

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8 55. The CMP method of claim 54, wherein the cationic
9 surfactant comprises a quaternary ammonium substituted salt.

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1 56. A CMP method comprising:
2 applying a solid abrasive material to a substrate;
3 polishing the substrate with the abrasive material;
4 after polishing, pressure spraying the substrate using a spray
5 solution comprising a surfactant material to flocculate and remove at
6 least a majority portion of the abrasive material.

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8 57. The CMP method of claim 56, wherein applying a solid
9 abrasive material comprises applying a CMP slurry comprising
10 substantially dispersed, solid abrasive material to the substrate and
11 polishing the substrate comprises polishing the substrate with the slurry.

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13 58. The CMP method of claim 56, wherein applying a solid
14 abrasive material comprises applying a polishing pad comprising solid
15 abrasive material to the substrate and polishing the substrate comprises
16 polishing the substrate with the pad.

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18 59. The CMP method of claim 56, wherein the abrasive material
19 comprises ceria.

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21 60. The CMP method of claim 56, wherein a temperature of the
22 substrate during the flocculating does not exceed about 40 °C.

1 61. The CMP method of claim 56, wherein the flocculating
2 further comprises complexing at least a portion of the abrasive material
3 with the surfactant material.

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5 62. The CMP method of claim 56, wherein the surfactant
6 material comprises a cationic surfactant.

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8 63. The CMP method of claim 62, wherein the cationic
9 surfactant comprises a quaternary ammonium substituted salt.

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1 64. A CMP method comprising:
2 applying a solid abrasive material to a substrate;
3 primary polishing the substrate with the abrasive material;
4 buffing the substrate along with applying a surfactant comprising
5 material to the substrate and flocculating at least a portion of the
6 abrasive material with the surfactant comprising material; and
7 removing at least a majority portion of the flocculated portion of
8 the abrasive material from the substrate.

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10 65. The CMP method of claim 64, wherein applying a solid
11 abrasive material comprises applying a CMP slurry comprising
12 substantially dispersed, solid abrasive material to the substrate and
13 polishing the substrate comprises polishing the substrate with the slurry.

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15 66. The CMP method of claim 64, wherein applying a solid
16 abrasive material comprises applying a polishing pad comprising solid
17 abrasive material to the substrate and polishing the substrate comprises
18 polishing the substrate with the pad.

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20 67. The CMP method of claim 64, wherein the abrasive material
21 comprises ceria.

1 68. The CMP method of claim 64, wherein a temperature of the
2 substrate during the flocculating does not exceed about 40 °C.
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4 69. The CMP method of claim 64, wherein the flocculating
5 further comprises complexing at least a portion of the abrasive material
6 with the surfactant comprising material.
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8 70. The CMP method of claim 64, wherein the surfactant
9 comprising material comprises a cationic surfactant.
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